# STUDIES OF DUCTLESS GLANDS BY THE ELECTRICAL METHOD

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A study of the conditions of activity in the ductless glands, which pass their secretions into the blood stream, is difficult because recognition of the secretion in the blood is uncertain or impossible. It has long been known that physiological activity is accompanied by the development of an electrical difference which may be manifested by connecting an active part with an inactive part through a delicate galvanometer. It seemed possible that by the application of this method important information might be obtained as to the conditions of activity of the ductless glands. This work has been carried on through the cooperation of Mr. McKeen Cattell.

The method was first justified by applying it to the submaxillary gland which has an external secretion. Because an electrical change accompanies the secretion of saliva even though the blood supply is shut off from the gland or the flow through the duct is stopped; and because the change is absent when secretion is absent, although each of the conditions attendant on secretion (such as contraction of blood vessels, relaxation of blood vessels, faster flow of blood, slower flow of blood) may severally be induced, the conclusion is drawn that the electrical change is a manifestation solely of the process of secretion.

The direction of this electrical current of action developed by the submaxillary gland may be reversed although the physiological responses to stimulation remain as usual. Reversal is not, therefore, a certain sign of a reversed physiological process in the gland.

When the action current indicates a maximal activity of the submaxillary gland excited by stimulating the sympathetic nerve in the neck (cat), the electrical response can be augmented by stimulating the chorda tympani nerve and vice versa; sympathetic impulses are ineffective during the height of an effect produced by injected adrenin, and chorda tympani impulses cause no increase of the action current while pilocarpine is strongly operative.

The method thus justified on the submaxillary gland has been applied to the thyroid. Histologists have described nerve fibers leading to the cells of this gland, and anatomists have reported that the fibers going to the thyroid gland arise in the cervical sympathetic ganglia. Previous investigators have shown that severance of its cervical sympathetic nerves causes atrophy of the thyroid, and stimulation of these nerves

causes a diminished iodine content of the gland. Severance of the vagus nerve supply has no effect.

If the thyroid gland and neighboring indifferent tissue are connected through a galvanometer, stimulation of the sympathetic strand high in the thorax evokes an action current after a latent period varying usually between 5 and 7 seconds. This effect persists after the superior and the recurrent laryngeal nerves are severed. Experiments have shown that the nerve impulses pass out through both the superior and inferior cervical ganglia.

Simulation of the main trunk of the vagus nerve in a curarized animal, or injection of pilocarpine (which excites vagus endings) has no effect in producing an action current in the thyroid gland.

The influence of sympathetic impulses is not indirect through local anemia of the gland, for when the blood supply is wholly stopped by clamping the blood vessels for a period equal to that of sympathetic stimulation, no noteworthy electrical change is produced.

The conclusion is drawn, therefore, that the nerves distributed to the thyroid cells belong to the sympathetic and not to the vagus supply, and that their effects are not indirect through alterations of blood flow, indeed that they are true secretory nerves.

It is known that the internal secretion of the adrenal gland, or adrenin, will have the same effect in the body as sympathetic nerve impulses. Injection of a small dose of adrenin, 0.1 to 0.2 cc. (1:100,000), evokes a marked action current in the thyroid gland. Also, stimulation of the nerve to the adrenal gland so as to cause its secretion to be poured into the blood stream, will evoke a characteristic electrical change in the thyroid. This electrical change does not occur if the return of blood from the abdomen is prevented, but takes place promptly when the pent blood is released. Furthermore, it fails to appear after stimulating these nerves if the adrenal glands have been previously removed. There is thus definitely established an influence of adrenal secretion on thyroid activity.

Previous studies have shown that the adrenal glands are roused to special activity in times of emotional stress. The thyroid gland is subject to the division of the nervous system which is brought into action in emotional excitement and which causes adrenal secretion. It is probable, therefore, that the thyroid, like the adrenal, has normally functions which are performed in times of critical emergency. It may be that such an emergency function is an exaggerated form of the routine activity of the gland.

The complete account of these researches will be published in the *American Journal of Physiology*, July, 1916.